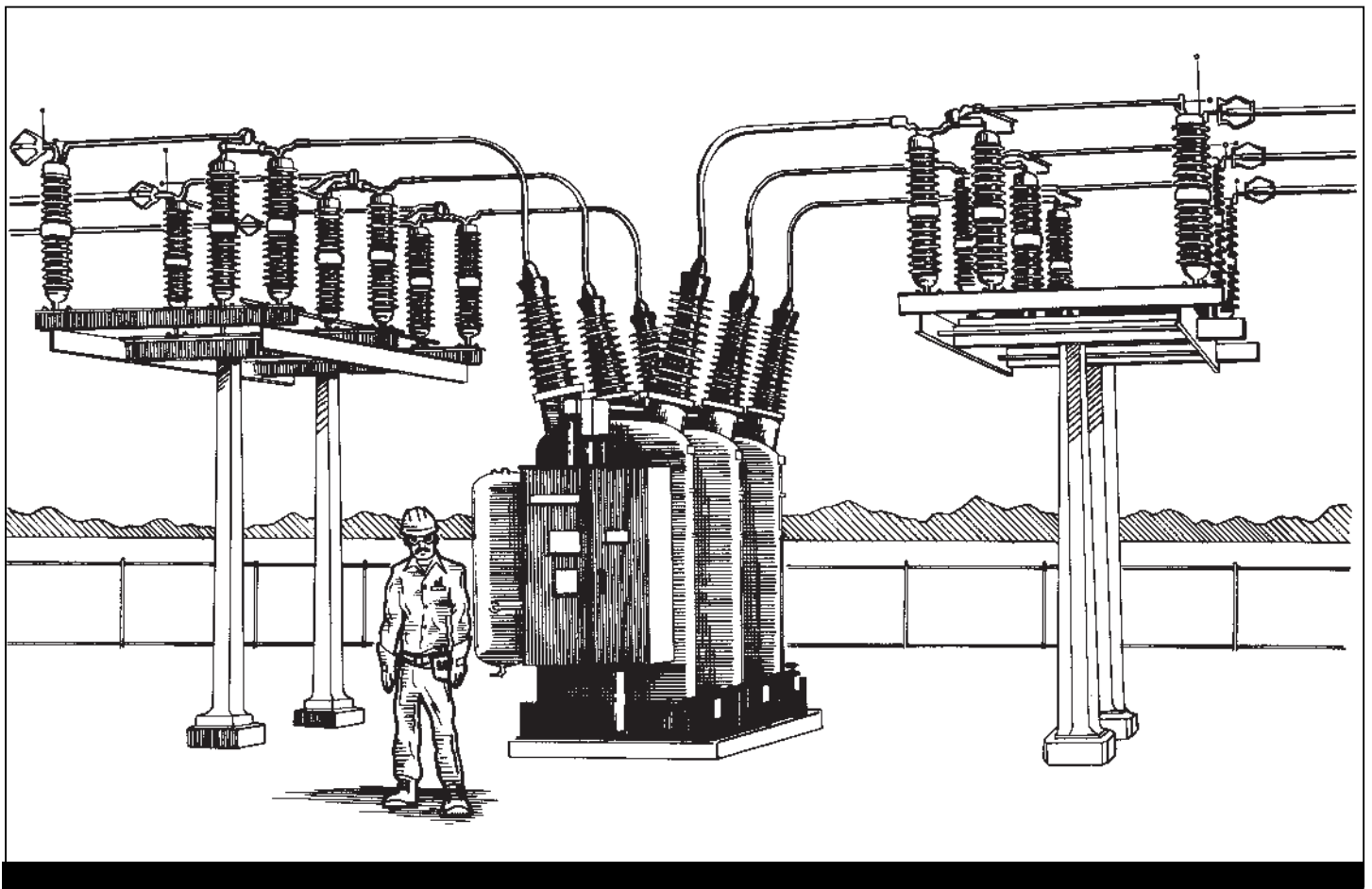


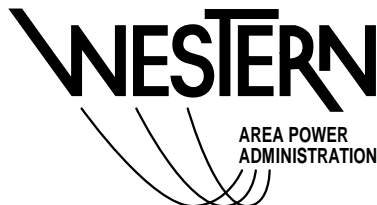
Chapter 13

# STANDARD MAINTENANCE GUIDELINES - SUBSTATIONS

March 1992



## Power System Maintenance Manual



# **STANDARD MAINTENANCE GUIDELINE SUBSTATIONS**

**MARCH 1992**

**WESTERN AREA POWER ADMINISTRATION  
POWER SYSTEM MAINTENANCE MANUAL  
CHAPTER 13**

**Approved for Publication and Distribution**

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*3/2/92*

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**Date**

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## INTRODUCTION

This manual contains standard maintenance guidelines for substation equipment. The standard guidelines list only the basic tasks to be completed during maintenance on a specific type of equipment. Other tasks considered necessary should be performed at the discretion of the Area or District. These guidelines do not replace the manufacturer's detailed instructions.

The development of the standard maintenance guidelines assures that all Western Area and District Offices are completing the same tasks for each maintenance job accomplished. Although the details and frequency of each task may vary due to differences in manufacturer's instructions, equipment design, age of equipment, number and severity of operations, etc., utilizing standard guidelines will enhance productivity and system reliability.

In addition to manufacturer's instructions, Western has a number of manuals to assist field personnel in safety and maintenance related issues. Safety rules and procedures can be found in the Power System Safety Manual (PSSM). Further safety and maintenance procedures are also discussed in the Power System Maintenance Manual (PSMM). For assistance on Maintenance Information System (MIS) codes, please refer to the MIS Daily Work Report User Manual.

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**EQUIPMENT CLASS (CLASS CODE):** None  
**JOB DESCRIPTION (JOB CODE):** Substation Inspection (SSI)  
**INSPECTION INTERVAL:** Determined by the Substation Classification Program

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Each category includes general items to be checked during an inspection of a substation. The order of the categories or the items listed under the categories may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job. This list does not replace any inspection forms already created, but serves as a guideline for items which should be addressed during substation inspections.

## **RECOMMENDED ITEMS FOR INSPECTION**

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- I. Fences and Yard
  - 1. Warning signs on fences
  - 2. Security (locks, alarms, fence, etc.)
  - 3. Yard lighting
  - 4. Weed abatement
  - 5. Soil erosion and contamination
  - 6. Oil containment and/or secondary containment
  - 7. Cable trenches
  - 8. Surface water monitoring systems
  - 9. General housekeeping
    - a. Rags, debris, etc.
    - b. Loose asbestos
- II. All Outside Equipment
  - 1. Oil leaks
  - 2. Counter readings
  - 3. Oil levels in bushings, tanks, and tap-changer compartments
  - 4. Gas pressures
  - 5. Operation of fans, heaters, and compressors
  - 6. Deterioration, rust, or other damage to buswork and support structures
  - 7. Solid ground connections
  - 8. Paint condition, PCB labels, and designation labels
  - 9. Condition of operating platforms
- III. Environmental Compliance
  - 1. Interior and exterior stored materials and wastes
    - a. Insulating oils and gases
    - b. Solvents and lubricants
    - c. Paints
    - d. Pesticides
    - e. Spare batteries and acids
    - f. Other chemicals or substances

- 
- 2. Storage containers
    - a. All barrels or containers (approved, properly documented, and labeled)
    - b. Secondary containment
    - c. Flammable materials cabinets
  - 3. SPCC plan — if required
  - IV. Buildings
    - 1. Overall structure (roof, floors, doors, gutters, downspouts, exterior walls, foundations, cable entries, paint, etc.)
    - 2. Heaters/air conditioners (temperature settings, timers, and filters)
    - 3. Water heaters and coolers
    - 4. Sinks, showers, toilets, drains, eye wash, and water supply
    - 5. Indoor lighting, emergency lights, and lighting covers
    - 6. Fire protection (service date on fire extinguishers)
    - 7. General housekeeping
      - a. Rags, debris, etc.
      - b. Loose asbestos
      - c. Ventilation of dust generation areas
  - V. Storage Batteries (PSMM, chapter 9, Storage Battery Maintenance)
  - VI. Battery Backup Systems
    - 1. UPS system
    - 2. Motor-generator base, windings, commutator, rings, brushes, shaft, and bearings
    - 3. Charger transformer or reactor
    - 4. Dial switch or rheostat
  - VII. Annunciator Board (abnormal indications)
  - VIII. Switchboards and Control Equipment (relay targets set)

It is recommended that a thermographic survey be conducted on an annual basis. Problems that are identified by the survey should be scheduled for repair.

It is also recommended that ground mat resistance testing be performed in accordance with PSMM, chapter 8, Ground Mat Resistance Testing Procedures.

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**EQUIPMENT CLASS (CLASS CODE):** Transformers - Power and Grounding (TRW), Phase Shifting (TRP), & Load Tap Changing (TRC)  
**VOLTAGE:** All Voltages  
**JOB DESCRIPTION (JOB CODE):** Complete Service (CSE)  
**MAINTENANCE INTERVAL:** 5 Years

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Each step listed includes general maintenance procedures to be followed during a complete service on a power transformer. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on transformer in accordance with instructions from test equipment manufacturers, transformer manufacturers, and established maintenance procedures. Test transformer oil and tap-changer oil if so equipped.

1. Oil tests (dissolved gas analysis, dielectric test, color test, acidity test, moisture test, and interfacial tension (IFT) test)
2. Turns ratio test (Omit this test for grounding transformers. For phase-shifting transformers, test to verify the phase angle shift.)
3. Power factor test
4. Test for gas in the nitrogen blanket (if applicable)

**Step 3 - External Inspection and Maintenance**

1. Inspection of the transformer includes the concrete pad, bolts, grounds, bushings, oil leakage, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits.
  - D. Test operating fans and pumps (if applicable).
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.
4. Perform tap-changer maintenance if so equipped.

**Step 4 -** If applicable, check the oil conservator system. Perform any necessary maintenance.



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**Step 5** - Drain and process oil if the oil tests indicate a problem. For phase-shifting and tap-changing transformers, drain the tap changer and inspect the contacts, spring mechanisms, operating cabinet, etc., per manufacturer's instructions.

**Step 6** - Internal Maintenance

1. Accessing the tank includes removing the cover, ventilating, testing the oxygen level, and visually inspecting the interior.
2. Check for loose bolts, winding blocking, and insulation condition. Also, check to ensure all leads are secured and properly placed.
3. Check for any signs of arcing or abnormal discoloration of the insulation that would indicate overheating.
4. Verify that all tools have been removed from the tank.
5. Replace cover and seal.
6. Vacuum the transformer, if so designed, to specifications.
7. Refill with oil to proper level.

**Step 7** - Place the Transformer in Service

1. Clean and/or repaint/touch up transformer.
2. Clean up work area.
3. Remove personal protective grounds.
4. Do a walk-around inspection.
5. Release clearance on transformer and return to normal status.
6. Place transformer back in service.

---

**EQUIPMENT CLASS (CLASS CODE):** Transformers - Power and Grounding (TRW), Phase Shifting (TRP), & Load Tap Changing (TRC)  
**VOLTAGE:** All Voltages  
**JOB DESCRIPTION (JOB CODE):** Partial Service (PSE)  
**MAINTENANCE INTERVAL:** 1 Year

---

Each step listed includes general maintenance procedures to be followed during a partial service on a power transformer. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on transformer in accordance with instructions from test equipment manufacturers, transformer manufacturers, and established maintenance procedures.

1. Oil tests (dissolved gas analysis, dielectric test, color test, acidity test, and interfacial tension (IFT) test)
2. Test for gas in the nitrogen blanket (if applicable)

**Step 3 - Test Operate and Service (If applicable)**

1. Test operate the cooling fans and repair if needed.
2. Test operate oil pumps and repair if needed.

**Step 4 - External Inspection and Maintenance**

1. Inspection of the transformer includes the concrete pad, bolts, grounds, bushings, oil leakage, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits.
  - D. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.
4. Test operate the tap changer if so equipped.

**Step 5 -** Check the nitrogen pressure (if applicable) and add nitrogen as required. Also check the oil conservator system (if applicable).

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**Step 6 - Place the Transformer in Service**

1. Test all alarms (including control center alarms) and switches.
2. Clean and/or repaint/touch up transformer.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on transformer and return to normal status.
7. Place transformer back in service.

---

**EQUIPMENT CLASS (CLASS CODE): SF<sub>6</sub> Gas Circuit Breaker (CIG)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**

**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on a gas circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform premaintenance diagnostic tests on breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Power factor insulation test
3. Motion analyzer (time travel) test (69 kV and greater only)
4. Trip test
5. Moisture test on the gas

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - For breakers equipped with pneumatic operators, drain and inspect the air tanks.**

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**Step 5** - Remove SF<sub>6</sub> gas from the breaker.

1. Transfer the gas from the breaker (use a gas processing unit).
2. Pull a vacuum on the breaker to ensure all of the gas has been removed.
3. Release the vacuum on the breaker with dry air or nitrogen to avoid pulling moisture into the tanks.

**Step 6** - Internal Maintenance

1. Accessing the tank includes opening the tank, vacuuming any residue (if present), ventilating, and wiping the inside of the tank with approved solvent.
2. Inspect all parts for wear and damage including the fiberglass components and seals.
3. Install factory-recommended overhaul and sealer kits. Replace all desiccant materials, if applicable.
4. Perform any repairs or adjustments.
5. Seal the breaker tank and pull a vacuum per manufacturer's specifications. If the vacuum holds for the specified amount of time, this indicates that no leaks are present.
6. Refill the tank to the proper pressure.

**Step 7** - Diagnostic Tests

1. Perform post maintenance diagnostic tests on breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.
  - A. Contact resistance test
  - B. Motion analyzer (time travel) test, if necessary
  - C. Power factor test
  - D. Trip test
  - E. Moisture test on the gas
2. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.

**Step 8** - Place the Breaker in Service

1. Clean and/or repaint/touch up breaker.
2. Clean up work area.
3. Remove personal protective grounds.
4. Do a walk-around inspection.
5. Release clearance on breaker and return to normal switching.
6. Place breaker back in service.

---

**EQUIPMENT CLASS (CLASS CODE): SF<sub>6</sub> Gas Circuit Breaker (CIG)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Partial Service (PSE)**

**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a partial service on a gas circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on the breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test (69 kV and greater only), if necessary
3. Power factor insulation test
4. Trip test
5. Moisture test on gas

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - Place the Breaker in Service**

1. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up breaker.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on breaker and return to normal switching.
7. Place breaker back in service.

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**EQUIPMENT CLASS (CLASS CODE): Oil Circuit Breaker (CIO)**

**VOLTAGE: 69 kV and Greater**

**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**

**MAINTENANCE INTERVAL: 69 kV = 2.5 Years**

**Greater than 69 kV = 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on an oil circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform premaintenance diagnostic tests on breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test
3. Trip test
4. Power factor (includes bushings, oil, etc.) test

**Step 3 - Filter the oil to remove both carbon and water.**

**Step 4 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, leakage from any gasket or opening, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 5 - For breakers equipped with pneumatic operators, drain and inspect the air tanks.**

**Step 6 - Internal Maintenance**

1. Accessing the tank includes removing the door, ventilating, visually inspecting the interior, and wiping down the tank and interior parts.
  2. Maintenance of the internal parts (contacts, interrupter assemblies, internal CT's, resistors, capacitors, and lift rods) includes checking, measuring, adjusting, aligning, and making repairs as needed. Lubricate all parts and components that are required to be lubricated. Replace any seals and gaskets if necessary. Replace all desiccant materials, if applicable.
  3. Reseal the tank.
  4. Refill the tank to the proper oil level and inspect for leaks.
-

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**Step 7 - Diagnostic Tests**

1. Perform post maintenance diagnostic tests on breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.
  - A. Contact resistance test
  - B. Motion analyzer (time travel) test, if necessary
  - C. Power factor (includes bushings, oil, etc.) test
  - D. Oil dielectric test
  - E. Trip test
2. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.

**Step 8 - Place the Breaker in Service**

1. Clean and/or repaint/touch up breaker.
2. Clean up work area.
3. Remove personal protective grounds.
4. Do a walk-around inspection.
5. Release clearance on breaker and return to normal switching.
6. Place breaker back in service.



---

**EQUIPMENT CLASS (CLASS CODE): Oil Circuit Breaker (CIO)**  
**VOLTAGE: 69 kV and Greater**  
**JOB DESCRIPTION (JOB CODE): Partial Service (PSE)**  
**MAINTENANCE INTERVAL: 1 Year**

---

Each step listed includes general maintenance procedures to be followed during a partial service on an oil circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on the breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test, if necessary
3. Oil dielectric test
4. Trip test

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, leakage from any gasket or opening, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - Place the Breaker in Service**

1. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up breaker.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on breaker and return to normal switching.
7. Place breaker back in service.

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**EQUIPMENT CLASS (CLASS CODE): Oil Circuit Breaker (CIO)**  
**VOLTAGE: Under 69 kV**  
**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**  
**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a complete service on an oil circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform premaintenance diagnostic tests on breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test
3. Trip test
4. Power factor (includes bushings, oil, etc.) test

**Step 3 - If necessary, filter the oil to remove both carbon and water.**

**Step 4 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, leakage from any gasket or opening, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 5 - For breakers equipped with pneumatic operators, drain and inspect the air tanks (if necessary).**

**Step 6 - Internal Maintenance (If necessary)**

1. Accessing the tank includes lowering the tank, visually inspecting the interior, and wiping down the tank interior.
2. Maintenance of the internal parts (contacts, interrupter assemblies, internal CT's, resistors, and capacitors) includes checking, measuring, adjusting, aligning, and making repairs as needed. Lubricate all parts and components that are required to be lubricated. Replace any seals and gaskets if necessary. Replace all desiccant materials, if applicable.
3. Reset the tank.
4. Refill the tank to the proper oil level and inspect for leaks.

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**Step 7 - Diagnostic Tests (If necessary)**

1. Perform post maintenance diagnostic tests on breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.
  - A. Contact resistance test
  - B. Motion analyzer (time travel) test
  - C. Power factor (includes bushings, oil, etc.) test
  - D. Trip test
2. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.

**Step 8 - Place the Breaker in Service**

1. Clean and/or repaint/touch up breaker.
2. Clean up work area.
3. Remove personal protective grounds.
4. Do a walk-around inspection.
5. Release clearance on breaker and return to normal switching.
6. Place breaker back in service.

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**EQUIPMENT CLASS (CLASS CODE): Air Circuit Breaker (CIA)**  
**VOLTAGE: All Voltages**  
**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**  
**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on an air circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on the breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test
3. Dielectric test
4. Moisture test

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - Internal Inspection**

1. Check the contacts for excessive wear and replace if necessary.
2. Check the interrupters and insulating parts for burns or cracks that may indicate thermal aging. Repair or replace if necessary.
3. Check the blast valves. Re-build if necessary.
4. Replace all desiccant materials, if applicable.

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**Step 5** - For breakers equipped with pneumatic operators, drain and inspect the air tanks.

**Step 6** - Place the Breaker in Service

1. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up breaker.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on breaker and return to normal switching.
7. Place breaker back in service.

---

**EQUIPMENT CLASS (CLASS CODE): Air Circuit Breaker (CIA)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Partial Service (PSE)**

**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a partial service on an air circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on the breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test, if necessary
3. Dielectric test
4. Moisture test

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - Place the Breaker in Service**

1. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up breaker.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on breaker and return to normal switching.
7. Place breaker back in service.

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**EQUIPMENT CLASS (CLASS CODE): Vacuum Circuit Breaker (CIV)**  
**VOLTAGE: Under 69 kV**  
**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**  
**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on a vacuum circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on the breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - Internal Maintenance**

1. Measure the contact wear.
2. Perform a power factor test.
3. Replace all desiccant materials, if applicable.

**Step 5 - For breakers equipped with pneumatic operators, drain and inspect the air tanks.**

**Step 6 - Place the Breaker in Service**

1. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up breaker.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on breaker and return to normal switching.
7. Place breaker back in service.

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**EQUIPMENT CLASS (CLASS CODE): Vacuum Circuit Breaker (CIV)**

**VOLTAGE: Under 69 kV**

**JOB DESCRIPTION (JOB CODE): Partial Service (PSE)**

**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a partial service on a vacuum circuit breaker. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on the breaker in accordance with instructions from test equipment manufacturers, breaker manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Motion analyzer (time travel) test, if necessary

**Step 3 - External Inspection and Cabinet Maintenance**

1. Inspection of the breaker includes the concrete pad, bolts, grounds, bushings, paint condition, and all connections.
2. Maintenance includes the following:
  - A. Checking all temperature and pressure switches to ensure operation at the proper values.
  - B. Checking gauge calibrations.
  - C. Lubricating, cleaning, adjusting, aligning, and checking control circuits, compressors, and pumps.
  - D. Verifying the correct operation of heaters.
  - E. Making any needed repairs.
3. Record all required gauge, meter, and counter readings.

**Step 4 - Place the Breaker in Service**

1. Test operate the breaker and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up breaker.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on breaker and return to normal switching.
7. Place breaker back in service.



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**EQUIPMENT CLASS (CLASS CODE): Air-Core Reactor (RSE or RSH)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**

**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on an air-core reactor. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 -** Perform visual inspections and maintenance in accordance with reactor manufacturer's instructions.

**Step 3 -** Check and tighten bolts.

**Step 4 -** Check the ground on and the condition of the guard fence where applicable. Repair as necessary.

**Step 5 -** Check connections and condition of winding. Varnish if needed.

**Step 6 - Place the Air-Core Reactor in Service**

1. Clean up work area.
2. Remove personal protective grounds.
3. Do a walk-around inspection.
4. Release clearance on reactor.
5. Place reactor back in service.

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**EQUIPMENT CLASS (CLASS CODE): Oil-Filled Reactor (RSE or RSH)**  
**VOLTAGE: All Voltages**  
**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**  
**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on an oil-filled reactor. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Visual Inspection**

1. Check and clean bushings
2. Check the gauges

**Step 3 - Diagnostic Tests**

Perform diagnostic tests on oil-filled reactors in accordance with instructions from test equipment manufacturers, reactor manufacturers, and established maintenance procedures.

1. Oil tests (dissolved gas analysis, dielectric test, color test, acidity test, moisture test, and interfacial tension (IFT) test)
2. Power factor test

**Step 4 - Test operate the fans and pumps.**

**Step 5 - Place the Oil-Filled Reactor in Service**

1. Clean up work area.
2. Remove personal protective grounds.
3. Do a walk-around inspection.
4. Release clearance on reactor.
5. Place reactor back in service.

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**EQUIPMENT CLASS (CLASS CODE): Capacitor (CAE or CAH)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**

**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a complete service on a capacitor bank. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Inspections**

1. Visually inspect the electrical connections and fuses.
2. Make sure that all insulators, bus supports, fuses, and capacitor bushings are clean.
3. Visually inspect bushings and cans for damage.

**Step 3 -** If applicable, perform any necessary diagnostic tests on transformer banks associated with the capacitors.

**Step 4 - Place the Capacitor in Service**

1. Clean up work area.
2. Remove personal protective grounds.
3. Do a walk-around inspection.
4. Release clearance on capacitor.
5. Place capacitor back in service.

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**EQUIPMENT CLASS (CLASS CODE): Voltage Regulator (VOL)**  
**VOLTAGE: All Voltages**  
**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**  
**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on a voltage regulator. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on voltage regulator in accordance with instructions from test equipment manufacturers, voltage regulators manufacturers, and established maintenance procedures.

1. Dielectric test
2. Total combustible gas test

**Step 3 - Visually inspect the bushings and clean the bushing connections.**  
- Check all gauges.

**Step 4 - Test operate the fans and pumps where applicable.**

**Step 5 - Internal Inspection**

1. Drain and filter tap-changer oil.
2. Inspect the contacts and other internal parts.
3. Perform any needed maintenance.
4. Refill the tap changer to the proper level.

**Step 6 - Place the Voltage Regulator in Service**

1. Test operate the voltage regulator. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up voltage regulator.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on voltage regulator and return to normal status.
7. Place voltage regulator back in service.

---

**EQUIPMENT CLASS (CLASS CODE): Voltage Regulator (VOL)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Partial Service (PSE)**

**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a partial service on a voltage regulator. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform diagnostic tests on voltage regulator in accordance with instructions from test equipment manufacturers, voltage regulators manufacturers, and established maintenance procedures.

1. Dielectric test
2. Total combustible gas test

**Step 3 - Visually inspect the bushings and clean the bushing connections.**

- Check all gauges.

**Step 4 - Test operate the fans and pumps.**

**Step 5 - Place the Voltage Regulator in Service**

1. Test operate the voltage regulator. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.
2. Clean and/or repaint/touch up voltage regulator.
3. Clean up work area.
4. Remove personal protective grounds.
5. Do a walk-around inspection.
6. Release clearance on voltage regulator and return to normal status.
7. Place voltage regulator back in service.

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**EQUIPMENT CLASS (CLASS CODE): Oil-Filled Recloser (LIN)**  
**VOLTAGE: All Voltages**  
**JOB DESCRIPTION (JOB CODE): Complete Service (CSE)**  
**MAINTENANCE INTERVAL: 5 Years**

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Each step listed includes general maintenance procedures to be followed during a complete service on an oil-filled recloser. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Diagnostic Tests**

Perform premaintenance diagnostic tests on recloser in accordance with instructions from test equipment manufacturers, recloser manufacturers, and established maintenance procedures.

1. Contact resistance test
2. Trip coil current test
3. Trip test

**Step 3 - Filter the oil to remove both carbon and water.**

**Step 4 - External Inspection and Cabinet Maintenance**

1. Inspection of the recloser includes the bolts, grounds, bushings, leakage from any gasket or opening, paint condition, and all connections.
2. Cabinet maintenance includes the following:
  - A. Checking gauge calibrations.
  - B. Lubricating, cleaning, adjusting, aligning, and checking control circuits.
  - C. Making any needed repairs.
3. Record all required counter readings.

**Step 5 - Internal Maintenance**

1. Drop the tank for internal access.
2. Maintenance of the internal parts (contacts, interrupter assemblies, resistors, and capacitors) includes checking, measuring, adjusting, aligning, and making repairs as needed. Lubricate all parts and components that are required to be lubricated. Replace any seals and gaskets if necessary.
3. Reset the tank.
4. Refill the tank to the proper oil level and inspect for leaks.

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**Step 6 - Diagnostic Tests**

1. Perform post maintenance diagnostic tests on recloser in accordance with instructions from test equipment manufacturers, recloser manufacturers, and established maintenance procedures.
  - A. Contact resistance test
  - B. Trip coil current test
  - C. Oil dielectric test
  - D. Trip test
2. Test operate the recloser and record the number of operations. The tests should include all alarms (including control center alarms), switches, and manufacturer's recommendations.

**Step 7 - Place the Recloser in Service**

1. Clean and/or repaint/touch up recloser.
2. Clean up work area.
3. Remove personal protective grounds.
4. Do a walk-around inspection.
5. Release clearance on recloser and return to normal switching.
6. Place recloser back in service.

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**EQUIPMENT CLASS (CLASS CODE): Oil-Filled Recloser (LIN)**  
**VOLTAGE: All Voltages**  
**JOB DESCRIPTION (JOB CODE): Partial Service (PSE)**  
**MAINTENANCE INTERVAL: 1 Year**

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Each step listed includes general maintenance procedures to be followed during a partial service on an oil-filled recloser. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - External Inspection**

1. Check all cables, bolts, grounds, bushings, and connections.
2. Check for any leakage from gaskets or openings.
3. Check the paint condition.
4. Clean up any oil spots.

**Step 3 - Filter the oil to remove carbon and water if necessary.**

**Step 4 - Place the Recloser in Service**

1. Clean and/or repaint/touch up recloser.
2. Clean up work area.
3. Remove personal protective grounds.
4. Do a walk-around inspection.
5. Release clearance on recloser and return to normal switching.
6. Place recloser back in service.



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**EQUIPMENT CLASS (CLASS CODE): Disconnect Switch (SWD or SWF)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Switch Maintenance (SWM)**

**MAINTENANCE INTERVAL: 6 Years**

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Each step listed includes general maintenance procedures to be followed during switch maintenance on a disconnect switch. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Step 1 - Safety and Clearances**

1. Develop and review the Job Hazard Analysis.
2. Hold a tailgate safety meeting.
3. Secure the necessary clearances and place personal protective grounds.

**Step 2 - Inspection and Maintenance**

1. Check for loose bolts and nuts, tighten if needed.
2. Examine the contact surfaces for wear or pitting.
  - A. To clean the contacts, use steel wool to polish. Wipe clean and apply grease to the surface.
  - B. If severe damage has occurred, replace damaged parts.
3. Examine the switch blade contact alignment and realign if necessary. Test operate as a unit (three phase operation).
4. Check all galvanized surfaces for chips. If chipping has occurred, use "Galvan-Ox" or equivalent as a touch-up.
5. Grease any parts equipped with grease fittings.

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**EQUIPMENT CLASS (CLASS CODE):** Storage Batteries (BAT or BAU)  
**VOLTAGE:** All Voltages  
**JOB DESCRIPTION (JOB CODE):** Station Battery and Charger Maintenance (BAT)  
**MAINTENANCE INTERVAL:** See Below

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Each step listed includes general maintenance procedures to be followed during service on storage batteries. The order of the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job. These procedures are fully outlined in chapter 9 of the Power System Maintenance Manual, Storage Battery Maintenance.

INTERVAL	RECOMMENDED MAINTENANCE PROCEDURES
<b>Monthly</b>	<ol style="list-style-type: none"><li>1. Visually check the general appearance and cleanliness of the battery storage system.</li><li>2. Check the ambient temperature and condition of the ventilating equipment.</li><li>3. Record the float voltage measured at the battery terminals.</li><li>4. Record the charger output current and voltage.</li><li>5. Record pilot cell data:<ol style="list-style-type: none"><li>a. Cell voltage.</li><li>b. Cell specific gravity and electrolyte temperature for lead-acid batteries, corrected for temperature.</li></ol></li><li>6. Check for evidence of corrosion at terminals or connectors.</li><li>7. Check for cell cracks and loose connections.</li><li>8. Check for evidence of voltage leaks to ground.</li></ol>
<b>Quarterly</b>	<ol style="list-style-type: none"><li>1. Perform the recommended monthly maintenance procedures.</li><li>2. Check 10 percent of intercell connection resistances chosen at random.</li><li>3. Record the voltage of each cell.</li><li>4. Record the specific gravity of each cell for lead-acid batteries, corrected for temperature.</li><li>5. Record the electrolyte temperature of one out of each six cells chosen at random.</li></ol>
<b>Annually</b>	<ol style="list-style-type: none"><li>1. Perform the recommended quarterly maintenance procedures.</li><li>2. Tighten all bolt connections to the specified torque requirements.</li><li>3. Record all cell-to-cell and cell-to-terminal connection resistances.</li><li>4. Perform an integrity test and, if convenient, thermographically scan the battery connections during the test to check for "hot spots."</li><li>5. Verify the accuracy of the charger panel voltmeter.</li><li>6. Check the integrity of the battery rack.</li></ol>
<b>Every 5 years</b>	<ol style="list-style-type: none"><li>1. Perform the recommended annual maintenance.</li><li>2. Perform a capacity test.</li></ol>
<b>Special Maintenance</b>	<p>If the battery has experienced abnormal conditions, such as a severe discharge or the age of the battery is nearing its useful life, the maintenance interval should be adjusted accordingly. The maintenance procedures should include as much of or all of the recommended monthly, quarterly, and annual procedures (including performing a capacity test, if necessary).</p>

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**EQUIPMENT CLASS (CLASS CODE): Battery Charger (BCH)**

**VOLTAGE: All Voltages**

**JOB DESCRIPTION (JOB CODE): Station Battery and Charger Maintenance (BAT)**

**MAINTENANCE INTERVAL: See Below**

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Each step listed includes general maintenance procedures to be followed during maintenance on a battery charger. The order of the steps or the procedures listed under the steps may vary at the discretion of the Area or District Office. Safety procedures for each step will not be mentioned, however, all safety requirements will be adhered to during the job.

**Monthly**

1. Record the charger output current and voltage.
2. Check the following items: ripple, current-limiter circuit, over-voltage, under-voltage, etc.

**Annually**

1. Verify the accuracy of the charger panel voltmeter.
2. Test alarms and automatic shutdown functions per manufacturer's instructions.
3. Clean the battery charger.